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RESEARCH ON ELEMENTARY PARTICLES

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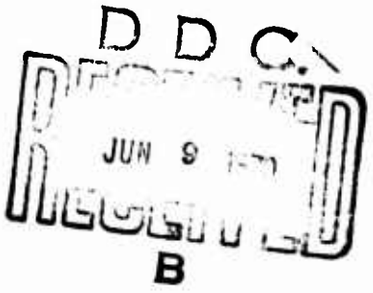

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ABSTRACT

The research work described in this report covers a large number of topics in the general field of theoretical elementary particle physics, including in particular Regge pole theory, current algebra, strong interaction dynamics and astrophysics.

CONTENTS

1. INTRODUCTION.

The research activity of the Imperial College theoretical physics group during the period covered by this report has been concerned with a wide variety of subjects connected with the theory of elementary particles.

Much of the work has been concerned in one way or another with Regge-pole model, either from a theoretical standpoint, or as a phenomenological tool for analysing experimental results. Another notable development is in the use of phenomenological Lagrangians, which have proved to be a convenient way of incorporating symmetries into the theory, and have yielded some very promising results.

2. PHENOMENOLOGICAL REGGE POLE MODELS.

A large group has been involved in the applications of Regge-pole theory. In particular the "multi-Regge model" of production processes has been used in several phenomenological studies. The model has been modified to take account of absorptive corrections. Extensive calculations have been undertaken using the model to fit experimental data. The results have been very encouraging, and have yielded significantly better fits than those obtained previously.

The Regge-pole model with absorptive corrections has also been applied with considerable success to several elastic and inelastic two-body scattering processes. This work has demonstrated the important role played by absorptive corrections in yielding results in good agreement with the experimental data.

3. SELF-CONSISTENT REGGE-POLE MODEL.

A theoretical analysis has been undertaken of the consistency conditions imposed by unitarity on a multi-Regge model. The scattering amplitudes for production processes are given by the multi-Regge model in terms of an assumed trajectory function and residue function. These amplitudes are then inserted in the unitarity equations, and yield constraints on the assumed functions. An iterative procedure is used to obtain a self-consistent solution. The existence and properties of this solution have been studied, yielding some very interesting results. It is especially noteworthy that large deviations from linearity of the trajectory functions are needed to obtain consistency.

4. SYMMETRIES.

Work on higher symmetries has continued. In particular these symmetries have been used to establish connections between the Regge parameters in different processes, yielding a Reggeised supermultiplet theory. This model has very few adjustable parameters, and the agreement obtained with experimental results is highly significant.

The special symmetries of scattering amplitudes at zero momentum transfer have also been studied. In particular the small breaking of this symmetry for momentum transfers close to zero has been investigated, yielding a number of interesting and useful conditions on the relevant parameters.

Group theoretical aspects of chiral symmetries have been studied using the techniques of differential geometry which yield in a simple and elegant way many interesting properties of chiral-symmetry theories.

5. PHENOMENOLOGICAL LAGRANGIANS.

One of the most straightforward methods of realizing the symmetries expressed by current algebra is through the use of suitable chosen phenomenological Lagrangians. In nontrivial cases, these Lagrangians are non-polynomial functions of the field variables. This is necessary because the fields generally belong to a nonlinear realization of the symmetry group. Methods for handling such Lagrangians have been developed, and their theoretical properties studied. A generally applicable technique has been obtained for renormalizing such theories, and a number of specific models have been examined in detail.

6. STRONG INTERACTION DYNAMICS.

The conditions imposed on scattering amplitudes for strongly interacting particles by the requirements of analyticity, unitarity and crossing have been investigated. In particular, the existence of functions satisfying exactly the requirements of crossing and unitarity has been rigorously established. The modifications required to the usual formalism for constructing the scattering matrix from its discontinuity function across the left-hand cut in the case where that function is unbounded have been found.

7. ASTROPHYSICS.

The possibility that in conditions of ultra-high density the speed of sound might exceed the speed of light has been subjected to further study, particularly in connection with oscillations of superdense stars. The theoretical situation in this regard is now much better understood.

8. CONCLUSIONS.

The Imperial College theoretical physics group has continued to be one of the most active centres of research in this field, and has contributed significantly to the progress of the subject. This is true especially of Regge-pole theory and the related topics described above. The recent work on phenomenological Lagrangians is particularly promising for future development.

In addition to the topics described above, individual members of the group have made important contributions in other directions. Notable among these are a study of certain aspects of the classical limit of quantum mechanics and several investigations of specific production and decay processes, particularly involving photons.

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